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POTATO GROWING

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INTRODUCTION

Potato growing is one of the leading industries of the state. Minnesota ranks among the five most important potato producing states in the Union. It also is one of the leading states in the production of certified seed. On account of the high standards required for certification and a rapidly developing general interest in the production of better potatoes, there has been a constantly increasing demand for information on potato growing.

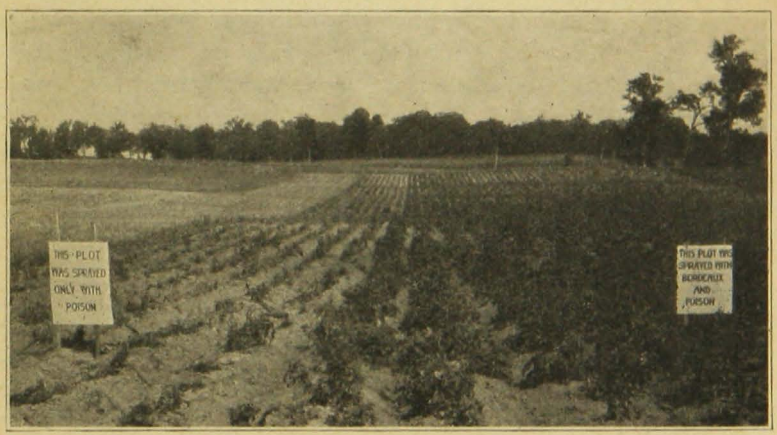

Fig. 1. Field of Early Ohio Potatoes
On right, plants show the effect of spraying with bordeaux mixture at high pressure, on left, effect of spraying with paris green only.

The potato is a cool-season crop. It can, however, be grown satisfactorily under a wide range of conditions by taking advantage of the cooler periods of the growing season. The cultivated crops suitable to

certain regions in the northern states at present hardly use all the cultivated land desirable in a rotation. Potatoes are the principal cultivated crop in these regions and their production tends to be highly competitive with a consequent narrow margin of profit.

Profitable returns from the potato crop can be had only by growing varieties that are adapted to the local conditions, by applying all available knowledge of the requirements of the potato plant, by the intelligent use of machinery in all phases of production, and by controlling insects and diseases which reduce the yields.

CONDITIONS DETERMINE VARIETIES TO BE GROWN

The choice of a variety adapted to the grower's soil and climate and which meets the requirements for his particular market, is one of the first essentials of successful potato growing. Eight varieties, each meeting certain specific commercial requirements, are recommended to the growers of Minnesota.

Early Ohio, the leading early variety, is grown extensively for the early market in the sandy soils north of the Twin Cities and for both seed and table use in the loam of the Red River Valley.

Irish Cobbler, a promising early potato, is grown mostly as seed stock for the south and to a lesser extent for table use. It is especially well adapted to peat soils in Minnesota.

Triumph, a round red early potato, is grown as seed stock for the south.

Rural New Yorker, a very widely grown, round, white, late potato, is a good yielding and keeping variety, an excellent market sort, suitable for almost any mineral soil. It matures late in the season and fits the requirements of central and southern Minnesota.

Green Mountain, a desirable late white potato, is similar to the Rural New Yorker but has a more oblong, rectangular tuber. It is better suited to rich heavy soils than the Rural New Yorker, as the tubers are not so likely to grow hollow. A popular variety in the north central and northeastern part of the state.

Burbank, a long, white, late potato of excellent quality, is suitable only for rich loose loam soils. It thrives well on virgin soils that are well supplied with humus. When well grown, it commands good prices.

Burbank Russet, a long russet late potato, differs from the Burbank principally in its heavily russeted skin. It is suitable for low, moist, friable, and peaty soils; a very fine quality potato for the home garden, and an excellent market variety when grown under favorable conditions.

Spaulding Rose (King), a broad, oblong, reddish potato, is recommended only for light sandy soils.

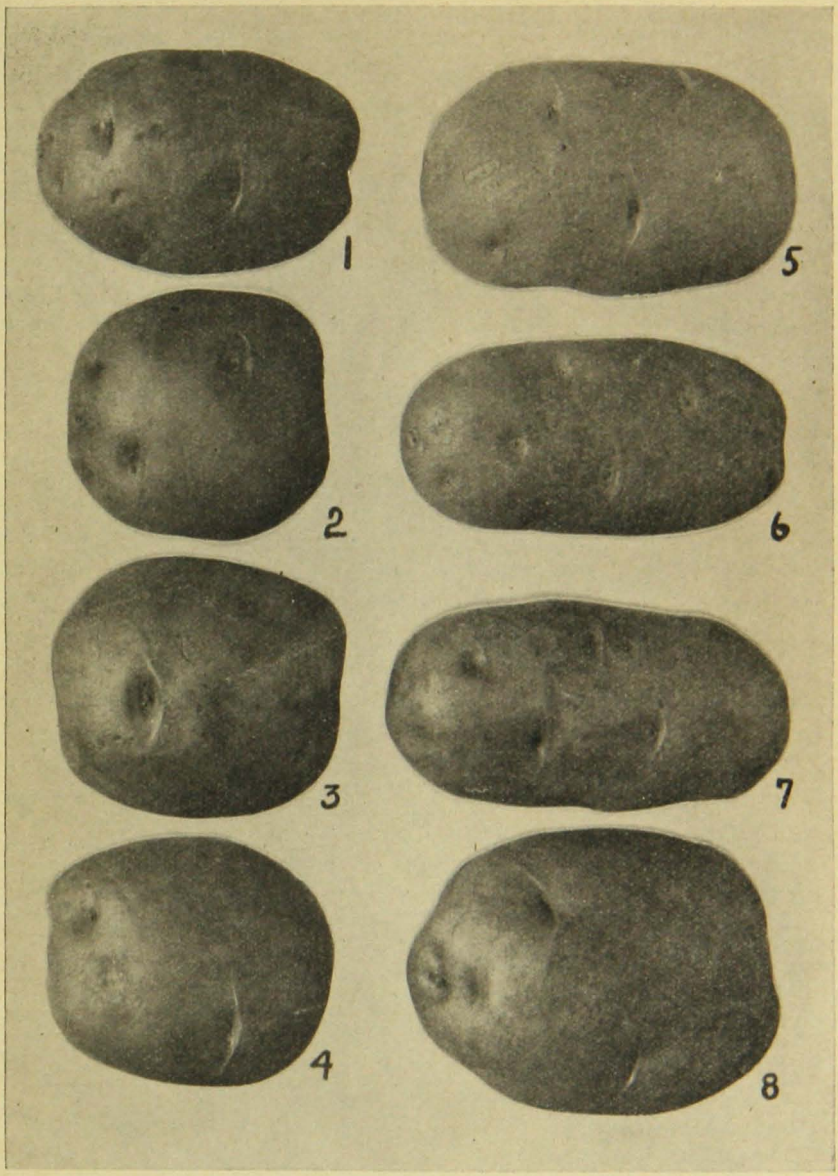

Fig. 2. Eight Standard Varieties of Potatoes Recommended for Minnesota

1. Early Ohio
2. Bliss Triumph
3. Irish Cobbler
4. Rural New Yorker
5. Green Mountain
6. Burbank Russet
7. Burbank
8. Spaulding Rose (King)

SEED MUST BE SELECTED WITH CARE

The use of good seed is one of the most important factors in potato production. Good seed is stock that is pure in respect to variety, produced by healthy vigorous plants whose tubers at planting time are firm and sound, with the first sprouts just beginning to develop. The so-called degeneration diseases, as mosaic, leaf roll, and curly dwarf, are generally found in the ordinary field grown from unselected stock. These diseases are usually not recognized by the average grower but they seriously affect the yield, often reducing it more than half. These diseases live from year to year in the seed tubers. Tubers from such a field never yield well.

A Seed Plot Is Necessary

The easiest way to get and keep good seed is by means of a seed plot. One acre in a seed plot will usually provide enough seed for ten acres of commercial planting. A plot separated from the main fields is desirable. If this is not convenient, enough rows may be planted in the potato field. For those who have not maintained a seed plot, it is usually desirable to get certified seed for the original planting of a plot. Certification is merely a record of seed stock that is of good type, highly productive and relatively free from serious diseases, as mosaic, leaf roll black leg, and wilt. Accurate information is obtained during field and bin inspections, of all factors which may affect the vigor of the stock under inspection. Requirements for eligibility to certification may be obtained from A. G. Tolaas, Chief Inspector, University Farm, St. Paul.

The seed plot should be inspected carefully several times during the growing season to detect and remove any possible mixture of varieties, and all weak and diseased plants. When harvested, the tubers from these rows should be stored in a separate bin and used for planting the commercial field the next year, after saving enough for the seed plot. The amount of work involved in such a seed plot is comparatively small, while the increased yields resulting from its use are relatively large. It is not necessary to be able to recognize potato diseases in order to maintain such a seed plot. All any grower needs is to be able to recognize plants that are not normal for the particular variety grown. If all abnormal plants are removed, the chances are more than even that most of the diseased plants will be eliminated.

TREATMENT OF SEED NECESSARY

All seed potatoes should be treated before planting. Treating is good insurance against blackleg, scab, and rhizoctonia, and pays no matter how clean the seed may appear to be. The germs which cause potato diseases are very small and to some extent are present on practically all tubers. If seed is planted without treatment much loss may result if the weather conditions are favorable for the development of diseases.

On the other hand, seed treatment is not an absolute guarantee against disease. The germs that cause scab and rhizoctonia live in the soil as well as on the tubers, and on badly infested soils the diseases may be severe in spite of seed treatment. Seed treatment kills only the disease on the tubers. Treated seed should not be planted on soil that has just yielded a badly diseased crop. In other words, seed treatment and a good system of crop rotation should go together. It is only in this way that the very best results may be obtained.

How to Treat Seed Potatoes

Sort all potatoes carefully before treating and discard all that are badly bruised or show the slightest signs of rotting. Treat before cutting and follow carefully the directions given below. Either of two methods may be used with good results. The hot formaldehyde method is quicker than the corrosive sublimate method and is recommended when large quantities of seed are to be treated. Farmers living in the same neighborhood often find it advantageous to establish a community treating tank. If the work is done on a large scale where steam is available, the temperature can be controlled more accurately and much labor is saved.

Corrosive Sublimate Method

1. Dissolve 4 ounces of corrosive sublimate (bichloride of mercury) in one gallon of warm water, using a stone crock or wooden bucket.

2. When thoroly dissolved dilute to 30 gallons in a wooden barrel or some non-metallic container.

3. Soak the tubers in this solution for an hour and a half; then remove them from the solution and spread out to dry.

4. Caution: **Corrosive sublimate is a deadly poison.** Do not use treated tubers for food. They will kill poultry, livestock, and human beings.

5. Do not treat the tubers in sacks, as the sacks weaken the solution.

6. The solution gradually loses strength with use. To correct this add one ounce of corrosive sublimate to each 30 gallons every time two lots have been treated in the same solution.

7. After treating eight lots, pour out the old solution and make up a new one.

8. Use only clean, disinfected containers or bins after treatment.

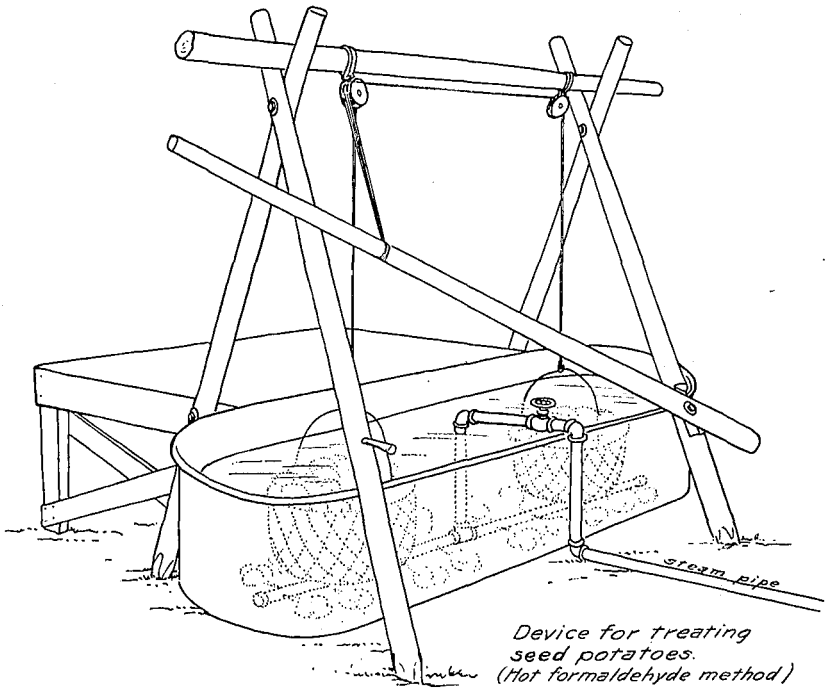

Fig. 3. Outfit for Treating Seed Potatoes with Hot Formaldehyde

Hot Formaldehyde Method

1. Make up the required amount of solution, using 2 pints of formaldehyde to each 30 gallons of water.

2. Put the solution into a tank so arranged that it can be heated to 120 degrees Fahrenheit. (This may be done by building a fire under the tank or by piping steam from a boiler into the solution. See Fig. 3.)

3. When the temperature of the solution is 120 degrees F., dip the tubers into the solution for two minutes.

4. It is better to use wire baskets or wooden crates than sacks.

5. After removing the tubers from the solution cover them for one hour; then cut and plant as soon as possible.

6. Keep the temperature of the solution between 118 and 122 degrees. If it is hotter it may injure the tubers. If it is colder it will not be so effective.

7. Use a good floating dairy thermometer to determine the temperature.

8. If steam is used to heat the solution, one sixth of a pint of formaldehyde should be added to each 30 gallons after treating each 100 bushels.

SIZE OF SEED PIECES IMPORTANT

Automatic seed-cutting machines are rapidly coming into use. Many types are on the market, ranging from those in which the tuber is placed in the proper position on the knives, to those which require only the necessary sizing on the part of the operator, the machine automatically adjusting itself so that each tuber is cut into blocky pieces of uniform size. Most seed potatoes, however, are cut by hand. When cutting, discard all tubers that are not firm and sound. The tuber should be cut into blocky rather than wedge-shaped pieces. Blocky seed pieces are more easily handled by the planter and are less likely to dry out or decay in the ground if the weather is unfavorable. It is generally advisable to cut the seed into uniform pieces weighing one or two ounces. Two to three ounce tubers when planted whole are excellent seed. Diseased plants usually produce only small tubers, therefore growers who want to use small tubers for seed must thoroly remove all diseased plants from the seed plot. Seed potatoes are generally cut just before planting. If cut in advance, care must be taken to avoid injury from heating.

POTATOES IN THE CROP ROTATION

A well balanced system of farming usually provides for several crops. Systematic rotation of these crops on the land conserves the fertility of the soil, improves its physical condition, helps keep down weeds, and at the same time prevents the development of injurious fungous and insect pests. Potatoes do best after a hay or pasture crop, which should be preferably a legume, such as the clovers and alfalfa. In cultivating a potato crop the land is at the same time prepared for a succeeding grain crop.

POTATOES NEED RICH SOIL

While some types of soil are better adapted to potatoes than others, the grower is interested usually in making the best use of the soil he has. A liberal supply of available plant food is necessary for profitable yields. Stable manure or commercial fertilizers may be used to supply this plant food. Either may be used alone or a commercial fertilizer may supplement a light application of manure. When a farmer can get the manure from his own stables it is the cheapest fertilizer. From 10 to 20 tons per acre can be applied either plowed under for potatoes or applied on the plowed land and worked in with the disk.

Commercial fertilizers are valued for the amounts of nitrogen, phosphoric acid, and potash which they carry. Stable manure carries all three. Some commercial fertilizers carry only one, some two, and others all three. One carrying all three is called a complete fertilizer.

If a commercial fertilizer is to be used for potatoes on mineral or ordinary soils, it is generally best to try one carrying all three nutrients such as a 4-8-6 or 2-8-5. The formula 4-8-6 denotes a fertilizer carrying 4 per cent ammonia, 8 per cent phosphoric acid, and 6 per cent potash.

The most convenient way to apply commercial fertilizer for potatoes is by means of an attachment on the planter. If this is not available it may be scattered broadcast on the surface and worked in before planting, or furrows may be opened and the fertilizer scattered in the furrows by hand. This should be covered with a rake or harrow and then the potatoes may be dropped and covered. If the application is to be heavy, as 1000 pounds or more per acre, it is advisable to broadcast at least half of this and disk it into the soil before planting, the rest being applied at the time of planting, with the fertilizer attachment on the planter. Burning and a poor stand are likely to follow when a very heavy application is made directly under and around the seed pieces.

On light sandy soils it is very doubtful whether commercial fertilizers can be used profitably. On many of the better sandy loams a suitable commercial fertilizer can be used with profit when fair prices are obtained for potatoes. Before buying for a large acreage, a farmer should try a fertilizer on a few rows on his own fields for a year or two to learn whether he can use it profitably. On sands and sandy loams, a complete fertilizer such as a 4-8-6 or a 2-8-5 should be tried at the rate of 500 to 800 pounds per acre

In western and northwestern Minnesota both a complete fertilizer and one carrying phosphate only should be tried. Many fields may be found which will give as much response to phosphate alone as to a complete fertilizer. In any such trials, the complete fertilizer should provide the same amount of phosphate per acre as is furnished by the acid phosphate alone. If 600 pounds per acre of a 2-8-5 fertilizer is used on the complete fertilizer plot, 300 pounds per acre of 16 per cent acid phosphate, or a little more than 100 pounds of treble superphosphate, should be applied on the phosphate plot.

In northeastern Minnesota a complete fertilizer such as a 4-8-6 at the rate of 400 to 800 pounds per acre, may be tried.

If growers in the central and southern portions of the state plan to grow potatoes on peat soil, they should use a combination of phosphate and potash, unless previous fertilizer trials have shown conclusively that one of these is unnecessary. Crops growing on peat soils are

always liable to injury from summer frosts and in general the farther north the peat is located the greater is the danger of injury from this source.

When any considerable area is to be planted, the fertilizer for peat soils can usually be bought most economically as acid phosphate and muriate of potash and then mixed. On soil that is being fertilized and cropped for the first time, the following applications per acre are recommended:

150 to 175 pounds of treble superphosphate or 420 to 500 pounds of 16 per cent acid phosphate or 325 to 400 pounds of 20 per cent acid phosphate	with	300 pounds of 50 per cent muriate of potash or 250 pounds of 60 per cent muriate of potash.

The larger amounts of phosphate used with the potash suggested would approximate an application of 750 pounds per acre of an 0-10-20 fertilizer. Applications up to 200 pounds of treble superphosphate and 400 pounds of 50 per cent muriate of potash per acre or even more, will often increase yields. On peat soil that has received moderate applications of fertilizer for clover or other crops, about the same application should be used for potatoes as recommended above or a somewhat lighter one if the previous applications have been heavy.

FALL PLOWING DESIRABLE

It is generally more desirable to plow in the fall than in the spring. Potatoes require a deep, compact, and fine seedbed. The roots of the potato plant do not grow readily in subsoil, so the seedbed must be deep to provide ample feeding area for the roots. A depth of from 7 to 8 inches is good, but if the soil has not been previously worked to this depth it would be inadvisable to plow more than an inch deeper than the previous plowings.

If the soil is in good physical condition, friable and well supplied with humus, it is easy to prepare an ideal seedbed for potatoes. In order to eliminate air spaces and allow the capillary water to rise freely to the surface of the soil, furnishing moisture to the roots of the plant, it is often advisable to disk the field before plowing. This forms a layer of loose soil from 3 to 4 inches deep. This pulverized top soil falls to the bottom of the furrow, preventing the formation of air spaces. It also establishes a close contact between the plowed soil and the subsoil, so that the upward movement of water may continue. Then by disking after plowing all the seedbed is pulverized. For smoothing,

leveling, and pulverizing the surface, nothing is better than a peg-toothed harrow, because it combines speed and efficiency with light draft. Its value in conserving moisture, in breaking up the surface crust after heavy rains, and in destroying weeds just after germination is well known to every farmer.

If the ground is fall-plowed and the following spring is late and cold, it is excellent practice to stir the field deeply with a spring-toothed harrow. This allows the warm air to circulate through the soil, warming it earlier. Following this with a peg-toothed harrow leaves the soil in good condition for the seed.

PLANTING

Potatoes do not yield well in hot weather. The crop should therefore be planted so as to allow for tuber growth either before or after the warmest part of the summer. Potatoes grown for the early market should be planted as soon as the soil can be prepared in the spring. The late or main crop should be planted so that the last four weeks of growth will be after the hot weather of midsummer and before the first killing frost in the fall. The early varieties require from 90 to 100 days to mature; the late varieties from 110 to 120 days.

In Minnesota, where level cultivation is best in order to conserve the moisture supply, the seed pieces should be planted deep enough to allow tubers to develop without danger of being exposed to sunburn. The seed pieces when planted should be in contact with cool moist soil.

CULTIVATION DESTROYS WEEDS, HELPS GROWTH

The principal object of cultivation is to destroy weeds. Other important benefits of cultivation are that it conserves moisture, frees plant food, allows air to pass through the soil, and encourages root action by loosening the soil and making it friable.

After planting, weed seeds will germinate before the potato plants come through the soil. A peg-toothed harrow used at this time will be more effective than several cultivations later, after the weeds have grown large enough to get a hold in the soil. And, best of all, the plant food and moisture that would have been stolen by the weeds will be held for the potatoes. When the plants appear above ground a harrow should be used wih the teeth slanting backward, or the plants may be injured severely. When the plants are large enough to show in the rows, the soil between them should be cultivated as deeply as possible. The next and each later cultivation should be shallower than the preceding one, and farther and farther from the plants.

Moisture is a limiting factor in the production of large yields of potatoes in Minnesota. In order to conserve the moisture the land should be left practically level after each cultivation. As a rule most growers, at the last cultivation, adjust the cultivator teeth or shovels so as to throw the soil toward the plants. This is done to protect from sunburn the tubers that are developing near the surface. Cultivation should stop when the plants are in bloom, or when the tubers are as large as a hen's egg, or whenever root pruning becomes severe.

SPRAYING IS A NECESSITY

Every year insects and diseases claim part of the potato crops—always a considerable amount, and much more than is ordinarily realized. Fortunately many of the insect and disease enemies of the potato can be controlled by spraying. Any of the arsenical insecticides, as arsenate of lead, arsenate of lime, arsenite of zinc, and paris green, are used for potato beetles and grubs. Bordeaux mixture is used for blights and also for those small sucking insects, the potato leaf-hoppers. The hoppers cause browning and burning of the leaves known as "hopper burn." Fortunately these arsenical insecticides and bordeaux mixture can be combined, and except for the first spraying, mentioned later, this combination is always recommended. If the combination is made it then becomes a matter of controlling two enemies at one spraying.

Liquid Spraying Better Than Dusting

Our experimental work has shown that the liquid spray applied under high pressure is better than any other form of application. Dusts have not given good results against the leaf-hopper and blights in Minnesota.

Rules for Making Bordeaux Mixture

Bordeaux mixture is made first as follows:

1. Make a copper sulfate stock solution by dissolving 24 pounds of copper sulfate (bluestone or blue vitriol) in 24 gallons of water in a wooden tub or barrel. The copper sulfate will dissolve quickest if suspended in a cloth bag just beneath the surface of the water. (Fig. 3.)

2. Make a quick-lime stock solution by slaking 24 pounds of quick lime in a few gallons of water and diluting to 24 gallons when the slaking is finished. Hydrated lime (builders' lime) may be used instead of quick lime, but 36 pounds will be needed to make 24 gallons of stock. Never use air-slaked lime.

3. Dilute 4 gallons of the copper sulfate stock solution to 25 gallons in a wooden tub or barrel.[1]

[1] If enough barrels or tubs are not available, the copper sulfate stock solution may be put directly into the spray tank and diluted to 46 gallons. Then add the quick-lime stock solution and stir vigorously. A more uniform product is obtained, however, when the two solutions are diluted separately.

Correction Slip for Special Bulletin No. 85

The following should be inserted on page 11 under the heading "Spraying is a necessity."

Any one of the following poisons, in the amounts named, may be added to 50 gallons of bordeaux mixture for spraying one acre:

Paris green, 1 pound	Zinc arsenite, 1¼ pounds
Calcium arsenate, 1¼ pounds	Lead arsenate, 1½ pounds

With the less effective one-nozzle sprayer, the amount should be doubled.

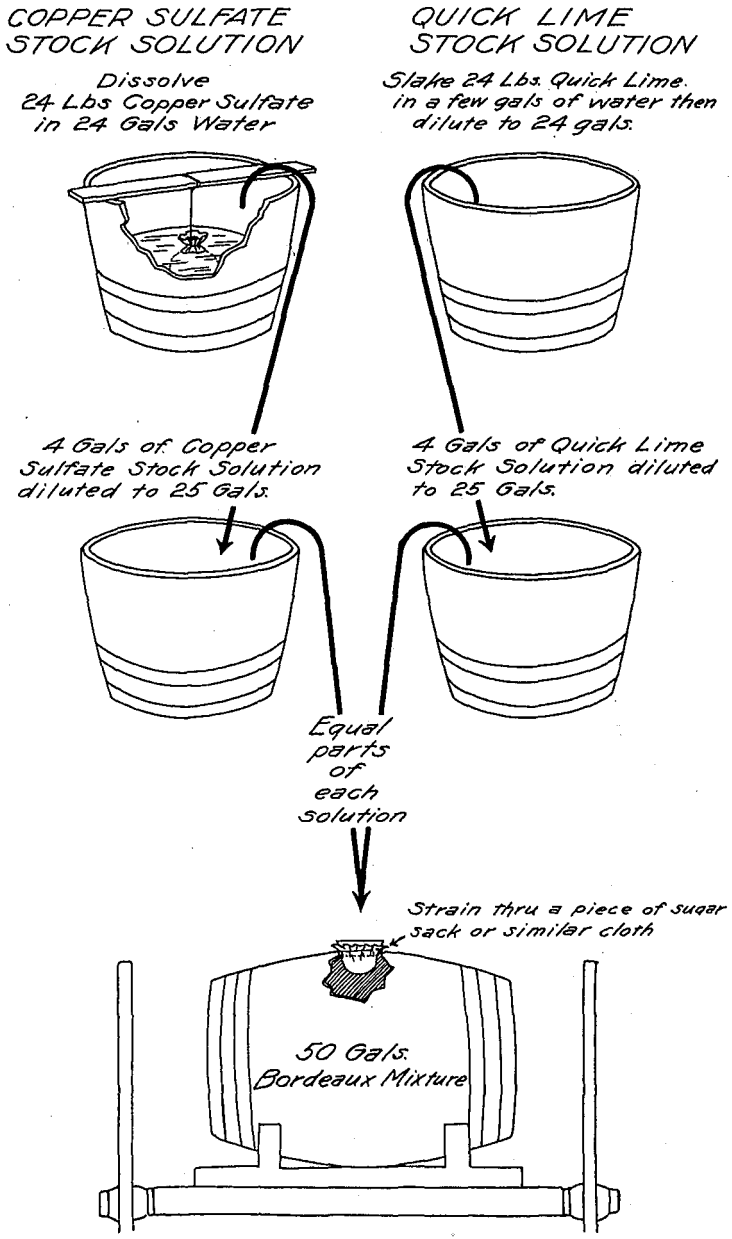

Fig. 4. Proper Method of Making Bordeaux Mixture

4. Dilute 4 gallons of the quick-lime stock solution to 25 gallons.

5. Pour these two solutions together into the spray tank to make 50 gallons of spray.

6. Always strain the solutions through a fine wire screen or a piece of cloth such as that used in sugar sacks. This prevents clogging the sprayer nozzles.

7. Use bordeaux mixture the same day it is mixed, as it will not keep. The stock solutions will keep for several weeks if kept covered to prevent evaporation.

When the bordeaux mixture is in the spray tank, just before it is to be applied, mix the required amount of arsenate of lead or arsenate of lime in a small quantity of water, stir thoroly until the material is nice and creamy, then pour it into the bordeaux mixture, stirring vigorously. Spray immediately.

There are several brands of commercial spray mixtures on the market. Most of them will give good results when properly applied and are very convenient when only small amounts are required. If large quantities of spray are needed, it is cheaper to make the bordeaux mixture as described.

Time to Spray Varies With Season

The time of spraying varies with the season and the time of planting. Sometimes it is necessary to apply the poison spray to control the beetles early in the season, before it is time to spray with bordeaux mixture. This should be applied just as the eggs are beginning to hatch. The combined arsenical spray and bordeaux mixture is usually applied for the first time about the middle of June when the plants are from 8 to 12 inches high. The object of the spraying from this time on is to keep the leaves of the plants covered with the spray material. Sometimes three sprayings are enough. Usually four sprayings are necessary, but in a wet season five are often required.

High Pressure Sprayer Gives Best Results

For the best results a high-pressure sprayer is necessary. Fairly good results can be obtained with low pressure, but experiments show that when a low-pressure sprayer is used much of the labor and cost of material are lost. The sprayer should develop two hundred pounds or more pressure, using three nozzles to the row. It is not necessary to purchase sprayers with gasoline engines. There are sprayers on the

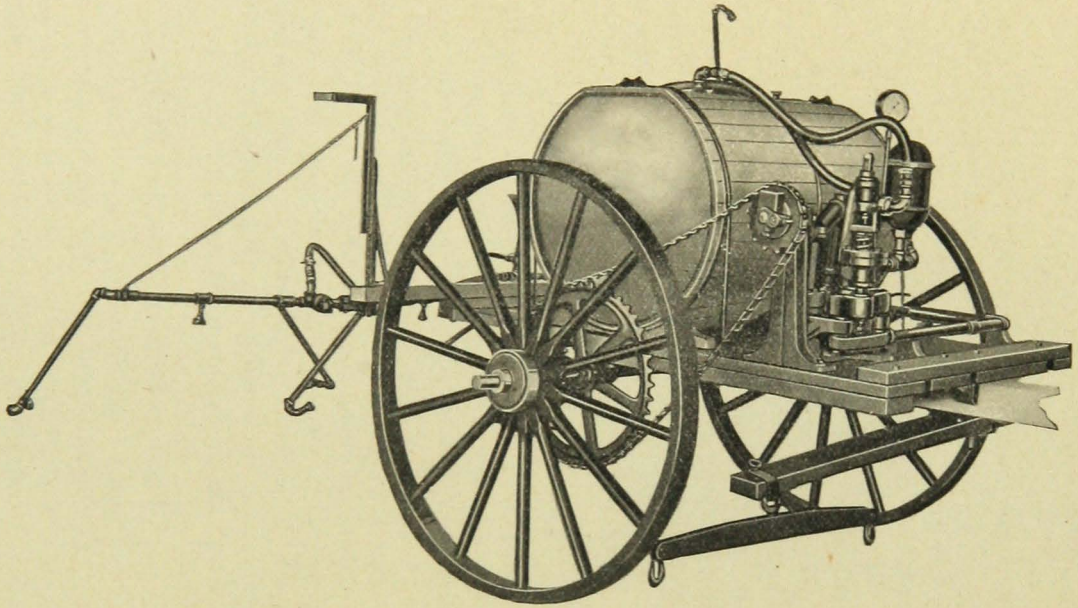

Fig. 5. High Pressure Traction Sprayer That Will Maintain 200 Pounds Pressure

market in which the traction of the wheels develops and maintains the pressure even if four rows are sprayed at one time and three nozzles to the row are used. (Fig. 4.)

Spraying With Bordeaux Mixture Pays

Experiments at University Farm and at several substations, extending over more than twenty years, have proved conclusively that bordeaux spraying pays. It is well known that potatoes could not be grown unless the potato beetles were controlled. We must spray for the beetles. Why not add bordeaux mixture with a slight extra expense and control as many pests as possible, and increase our yields still more?

If these pests are controlled, and we know they can be, the evidence is clear that the yield will be increased at least 25 per cent, often much more. This means that if proper spraying precautions are taken, less acreage need be planted to produce the same crop. With the great saving of time and labor this will result in a crop costing less per bushel and a greater profit will result.

TIME FOR HARVESTING VARIES

Potatoes grown for the early market are usually dug while the vines are still green. It is usually desirable not to dig the late crop for a week or ten days after the vines have matured or have been killed by frost. This allows the skin of the tubers to become hardened, and reduces the danger of bruising in harvesting.

The potato crop is dug with machines. If the acreage is small a simple plow-like digger may be used to harvest the crop. On the larger acreages the crop is harvested by the elevator type of digger for which three or four horses are required. If the machinery is driven by a small gasoline engine mounted on the digger, two horses are enough. Unnecessary bruising should be guarded against in digging the crop. No design of digger is entirely satisfactory for all types of soil. Before purchasing a digger, a grower should satisfy himself that the particular design of machine will work under his conditions and that it will not unnecessarily bruise the tubers.

Care in handling potatoes begins at time of harvesting. Potatoes contain a considerable amount of moisture. The skin, which is a corky layer surrounding the tuber, prevents the water from escaping into the atmosphere. It also prevents organisms which cause rot and decay from entering the tuber. The loss in weight from very slightly bruised tubers has been found to be 2 per cent greater in storage than the loss from unbruised tubers. The loss in weight is very rapid the first week after bruising, and slower after that, as the wounds gradually heal over.

It was ten weeks before the surface healed over sufficiently to reduce the loss of moisture to that of sound tubers. The fact that the greatest loss of weight occurs immediately after the tuber is wounded means that the grower can not hope to escape the loss caused by any unnecessary bruising of the potatoes during harvesting. Leaving the tubers in the ground for a short time after the vines have died or have been killed by the frost will allow the corky layer composing the skin to reach its normal development. When the tubers are dug the skin is frequently somewhat soft from contact with moisture in the soil. A few hours of drying in the sun after digging will harden it. The heavy losses from rough handling, cuts, bruises, and consequent decay, are usually not realized by the grower.

POTATO GRADING IS DESIRABLE

Potato grades are necessary in the commercial handling of potatoes. If the buyer personally inspects the potatoes at time of purchase or buys by sample, grades may be unnecessary, but the majority of sales are made "unsight and unseen" and it is necessary to define the character of the potatoes either by grades or description.

To provide market standards in potatoes, grades have been recommended by the United States Department of Agriculture.[2] Four grades are recognized: U. S. Fancy No. 1, U. S. No. 1, U. S. No. 1 small, and U. S. No. 2. These grades are based on size; similarity of varietal characteristics; freedom from dirt or other foreign matter, frost injury, sunburn, second growth, growth cracks, cuts, scab, blight, soft rot, dry rot, and damage caused by disease, insects, or mechanical means.

The so-called grading machines are simply sizing machines. They can not grade as to quality, and requirements affecting characters which collectively are usually designated as quality make up the larger part of "grade" specifications. It is interesting to note that in a study made by the Division of Agricultural Economics on 566 rejected cars shipped in 1920-21, 87 per cent of the rejections were because of other causes than under-size. The amount of money lost to growers, dealers, and consumers each year through the shipment of ungraded or poorly graded potatoes can not be estimated.

It pays to grade carefully for quality as well as for size. To do this effectively a large apron or table on the sizing machine is necessary in order that the operator or sorter may have time to remove all defective stock before the potatoes go on the belt or other sizing device.

[2] For grade specifications write to State Department of Agriculture, State Capitol, St. Paul, Minn.

STORAGE HELPS TO ASSURE PROFITS

The potato grower may store only enough for his own needs or he may store all or a part of his commercial crop. Most growers would find it desirable to have storage facilities on the farm to provide for at least half the crop over winter and for most of the crop for a short time in the fall. With such storage the crop can be dug more quickly, as time can be saved in hauling, and the potatoes can be held in the farm storage over winter or until cars are available for shipping. This eliminates danger of frost which frequently causes much loss. Storage should not be provided wholly for the sake of insuring a greater price, which is not always certain, but to prevent loss of the crop and to allow for marketing after the season's work is over.

Handling the Tubers Previous to Storage

Good storage begins at digging time. Care should be taken to avoid bruising the tubers in digging or in handling. Every normal tuber is covered with a corky skin which is waterproof and can resist the attack of the organisms causing decay. When this skin is broken water escapes and a way is provided for the entrance of rot-producing organisms. If bruised tubers are exposed to the dry air for a few hours they will usually heal over and become more resistant to decay. Potatoes should be thoroly dried before being put in storage.

Essential Factors Involved in Storage

There are three factors which it is necessary to control within certain limits to insure good storage, namely, temperature, aeration, and humidity. All of these can be controlled in our northern climate by proper construction of the storage place and a good system of ventilation. The temperature should be kept between 32 and 40 degrees F. This prevents sprouting, retards development of tuber rots, and reduces chemical activities within the tuber, preventing excessive loss through respiration. Potatoes stored at this temperature tend to become sweet, as the starch in the potato changes to sugar. A week or two weeks' exposure to ordinary room temperature (about 65 degrees F.) will bring the tubers back to their normal condition.

The ventilation provided should be sufficient to keep the tubers dry. Air saturated with moisture is not injurious to the potato, but it is favorable to the growth of molds which in time cause decay.

Three Common Methods of Storage in Use

Potatoes are stored in pits, cellars, or warehouses. By careful construction and attention the contents may be kept in good condition throughout the storage season in any of the three.

Potato pit.—A potato pit made in well drained soil and covered with alternate layers of straw and earth is a very good place for storage and has been used with splendid success in most localities where potatoes are grown. It seems to be a close approach to one of nature's methods of storing seed for the next year. It is, however, not very convenient to remove a part of the contents from a pit during cold weather, and this method of storage does not always prevent disaster, in case of exceptionally cold, warm, or wet weather. A good pit may be made about 4 feet deep and 6 feet wide and as long as is necessary. It will hold 100 bushels if 5 feet long. A 6x6-inch ventilator, 3 feet long, every 5 feet, will insure ventilation.

Storage cellar.—When more careful observation and accessibility is desired, storage cellars are constructed. Usually a knoll is the site chosen, as it insures drainage, ease of covering, and accessibility. The temperature of the earth varies much less than the temperature of the air, and this is utilized in pit storage. The storage cellar plan shown in Figure 6 is for the farmer who desires to keep at least a part of his crop until spring. The construction is such that a permanent storage cellar which will cost little for upkeep is secured. The work can be done by any one familiar with good concrete construction. The reinforcing should be carefully placed, so there will be no cracks or defects.

The cellar is built into the side of a knoll and the earth covers it about 3 feet deep. Its outside dimensions are 12x25 feet with a 7½-foot ceiling. The bins each have an approximate capacity of 360 bushels and by filling the center alley, more than 800 bushels may be stored. The vestibule is to allow entrance without a stairway, and by the use of a wheel truck much effort may be avoided at filling time. In some cases it may be desirable to fill through the roof by means of hatchway doors. At filling time the use of a screen door may be desirable, letting the air pass through rapidly until the potatoes have been cooled and the excess moisture removed. It will not be necessary to close the doors until late in the fall.

After the doors are closed the ventilation should be controlled and in severe weather the outlets should be closed. The intakes, if the slope of ground permits, come in horizontally and the air passes around the bins, which are separated from the floor and walls by 1x4-inch boards nailed to 2x4-inch material. It is desirable that the slatted floor be made in sections, to be removable in the spring so that the concrete floor may be easily cleaned. An earthen floor is entirely satisfactory in many localities, but is not so easily kept in good condition.

If the required capacity is large it is often desirable to have a driveway lengthwise of the building between two rows of bins. A row of posts at each side of the driveway supports the roof and also furnishes support for the walls of the bins. A building with this arrangement should be at least 24 feet wide, and the driveway 8 or 10 feet wide.

The warehouse.—Many growers find it convenient to have storage facilities for their commercial stock at the track. Frequently a group of growers own and operate a large warehouse. These warehouses offer many advantages to the grower. Economical and efficient grading and sacking of the potatoes preparatory for final shipment can be made. They afford temporary storage facilities in the fall when the supply of cars may be irregular. They also allow for orderly marketing throughout the season, as shipment can be made at any time during the winter. In the construction of these warehouses a proper regard for the factors affecting tubers in storage is necessary.

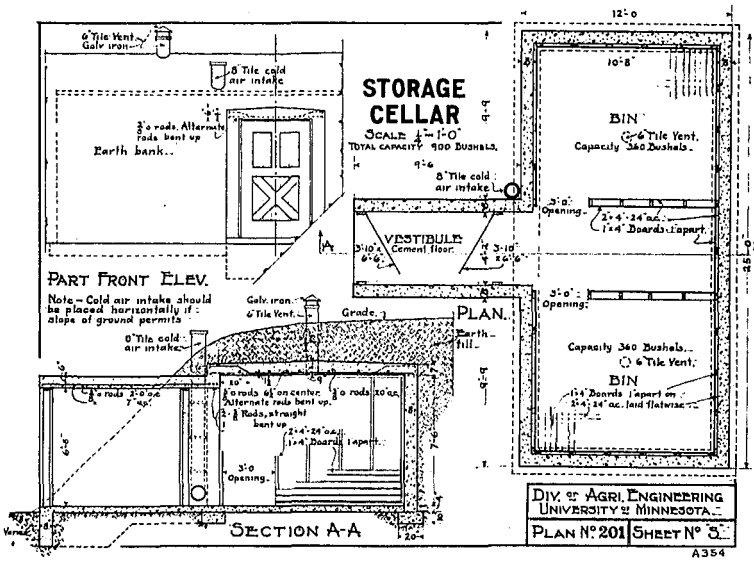

Fig. 6. Plans for a Storage Cellar with a Capacity of 900 Bushels

Further information about the construction of warehouses, cellars, and pits may be obtained by writing the Division of Farm Engineering, University Farm, St. Paul, Minn.

Operation of a Storage Cellar

It has often been said that, regardless of the type of storage, its efficiency depends to a great extent on the man who operates it. Following are a few of the precautions necessary. All possible air circulation should be given the storage cellar in the early fall by keeping ventilators

and doors open until there is danger of freezing On warm days the doors should be kept closed during the day and open only at night when the air is cooler When danger of freezing at night begins, the cellar should be open only during the day Sunlight should be excluded to prevent sunburn Early in December all ventilation should be shut off and ventilators and doors protected to prevent freezing The low temperature from this time on will eliminate the necessity for further aeration until spring weather arrives

Keep the storage cellars clean Many losses of potatoes in storage are due to rots which develop as a direct result of putting tubers in dirty and unsanitary bins The cellar should be so constructed as to make it easy to clean out every fragment of refuse before putting in the new tubers After all refuse has been removed, the floors, walls, and bins should be thoroly disinfected by washing or spraying with a solution of formaldehyde (one pint in 10 gallons of water) or copper sulphate (one pound in 10 gallons of water) Unless this is done the fungi and bacteria which cause tuber rots will multiply and spread to the stored tubers